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Behavioral responses of the pampas deer (*Ozotoceros bezoarticus*) to human disturbance in San Luis province, Argentina

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Abstract. The pampas deer *Ozotoceros bezoarticus* (Linnaeus, 1758) is a South American cervid, associated with grasslands and savannas; in Argentina this species is listed as "endangered". Our aim was to analyze the behavioral responses of the pampas deer to human presence, and to evaluate possible effects of their poaching. We recorded behavioral responses from 382 pampas deer groups during eight vehicle surveys, in "El Centenario" ranch (San Luis Province). Data were analyzed using the G-test of independence and logistic regression. Almost half of the groups (48.17 percent) remained on site. Behavioral responses differed significantly according to group size and composition and observer distance, with the last variable having the greatest influence on flight - groups were more likely to flee at shorter distances. Behavioral responses were independent from habitat type, transect type and season. Our results suggest certain human tolerance and that consequently, poaching has not had important effects on this population.

Key words: pampas deer, distance to observer, group size-composition, human tolerance, poaching.

The pampas deer *Ozotoceros bezoarticus* (Linnaeus, 1758) is an endemic South American species typical of open environments (Merino et al. 1997). This species was widely distributed, but in the early 20th century its populations suffered a strong numerical and geographic reduction (Demaría et al. 2003), due to habitat modification and increasing hunting pressure (González et al. 2010). The pampas deer is considered "near threatened" (NT) according to the IUCN Red List (González & Merino 2008), but in Argentina it is listed as "endangered" (Pastore 2012).

In Argentina, pampas deer inhabited a wide distribution area (Jackson 1987), however today only four isolated populations remain (Miñarro et al. 2011). This study was focused on the population of San Luis, where agricultural activities have increased since the 1990s; nevertheless, the population size in the core distribution area was not affected by the intensified farming activity (Merino et al. 2011). This species has maximum protection; although their hunting is prohibited in the area, local residents report poaching on the paved roads (Miñarro et al. 2011).

The goal of this paper was to analyze the behavioral responses of the pampas deer in San Luis when they detected the presence of an observer, and to evaluate the possible effects of poaching.

Study area. The population of San Luis inhabits the semi-arid Pampean grasslands, a graminaceous steppe with small chañar (*Geoffroea decorticans*) patches (Anderson et al. 1970); 80% of annual precipitation falls between October and April (Berton & Echeverria 1999). "El Centenario" cattle Ranch where this study was accomplished hosts the largest pampas deer nucleus of San Luis (Dellafiore et al. 2003). Currently, only 18% of the ranch has natural grasslands, whereas the exotic digit grass (*Digitaria eriantha*) and African lovegrass (*Eragrostis curvula*) occur in the rest of the grasslands; there are also small patches of crops (Merino et al. 2009, 2011).

Analysis of the behavioral response. Eight terrestrial surveys were conducted from a vehicle (30 kmh^{-1}) along seven fixed transects with variable length (10-38.4 km), defined by the distribution of paved and dirt roads. Each transect was traveled once per survey, covering a total of 136.5 km. The eight surveys were performed in January and April 2010, 2011 and 2012 (coincident with rutting peak), November 2010 and October 2011 (birthing peaks) (Ungerfeld et al. 2008a, b).

We recorded group size and composition; group was defined following Netto et al. (2000). Four group types were defined according to their composition: juveniles; adult males; adult females, with or without fawns/juveniles; and mixed, with or without fawns/juveniles. The age-sex classes follow Moore (2001).

Three possible behavioral responses were defined according to the attitude of groups when detecting our presence: -flee: immediately run away; -walk away: slowly moved away; -remain: stayed in place and proceeded with their activities. The distance from the center

of the group to the line transect was calculated using a rangefinder. In addition, we also recorded habitat and transect type.

Frequency of response was tested through a G-test of independence (Zar 1999), analyzing the group behavior depending on distance to observer, group composition, group size, habitat type, transect type and season. For analyses, responses -walk away and -remain were aggregated. Then, to assess if particular variables deviated from their expected values, the adjusted residuals of each cell were examined (Agresti 2002).

Lastly, groups responses (0: no response, 1: flight) were analysed with logistic regression, considering all the main factors simultaneously. We can not ensure independence of the data; therefore this represents a limitation in our study.

We observed a total of 382 groups, with an average of 47.75 groups per survey (1SD:12.82, *n*=8). Remain was the most used behavioral response (48.17%), followed by flee (32.46%). Flight responses occurred at a mean distance of 80.23 m (1SD:58.03, *n*=124) from the vehicle, in contrast to sighted groups that did not flee (120.54 m, 1SD:28, *n*=258).

The group response when detecting our presence, according to their size and composition, transect type, habitat type, season and distance to observer is shown in Table 1; groups tended to remain in all situations. Response differed significantly among groups of different size (G=12.347, 3DF, p=0.006), with solitary individuals fleeing more and staying/walking less than expected, and with groups ≥4 staying/walking more and fleeing less than expected (Table 2). Response was also dependent on group composition (G=16.18, 3DF, p=0.001), female groups fleeing more and staying/walking less than expected, with the opposite occurring in mixed groups (Table 2); mainly during November 2010 ($females_{flee}$:62.5%, $mixed_{flee}$:11.11%).

Significant differences were also found among distance to observer (G=16.244, 3DF, p=0.001), fleeing more than expected when distance range was 0–99 m and less than expected at ≥200 m (Table 2). On the other hand, behavioral response were independent from habitat type (G=2.804, 1DF, p=0.094), transect type (G=1.566, 1DF, p=0.211) and season (G=0.685, 2DF, p=0.71).

The model logistic that best explained the response to observer included the distance, group size, and group composition (Chi-square=31.38, 9DF, p<0.0001), with distance being the variable with the greatest effect (200-299m: p=0.031; ≥300m: p=0.023) with a strong negative influence on flight.

Results showed that in our presence, most of the groups remained on site and continued performing normal activities. The reaction of an individual may differ depending on their habituation

Table 1. Behavioral response of pampas deer groups (%) when detecting the presence of an observer, according to the group composition, transect type, habitat type, group size, distance to observer, and season.

		Behavioral response		
		Walking/ staying	Fleeing	Total
Group composition	Juveniles	52.94	47.06	100
	Adult males	65.52	34.48	100
	Adult females	60.61	39.39	100
	Mixed	81.42	18.58	100
Transect type	Dirt road	68.64	31.36	100
	Paved road	59.09	40.91	100
Habitat type	Grassland	64.06	35.94	100
	Crop	72.12	27.88	100
Group size	1	58.50	41.50	100
	2	68.07	31.93	100
	3	76.56	23.44	100
	≥4	80.77	19.23	100
Distance range	0 - 99	61.76	38.24	100
	100 - 199	71.43	28.57	100
	200 - 299	86.96	13.04	100
	≥ 300	91.30	8.70	100
Season	Autumn	69.44	30.56	100
	Spring	68.67	31.33	100
	Summer	65.16	34.84	100

Table 2. Adjusted residual values of number of pampas deer groups realizing the different behavioral responses, with respect to: A: group size, B: distance to observer and C: group composition, in "El Centenario" Ranch (General Pedernera Department, San Luis). Values displayed in bold are significant at the level alpha= 0.05.

	Group size	Walking/staying	Fleeing
	1	**-2.983**	**2.983**
	2	0.148	-0.148
	3	1.690	-1.690
A.)	≥ 4	**2.192**	**-2.192**

	Distance to observer	Walking/staying	Fleeing
	0 - 99	**-3.099**	**3.099**
	100 - 199	0.954	-0.954
	200 - 299	**2.052**	**-2.052**
B.)	≥ 300	**2.511**	**-2.511**

	Group composition	Walking/staying	Fleeing
	Males	-0.458	0.458
	Females	**-2.524**	**2.524**
	Mixed	**3.754**	**-3.754**
C.)	Juveniles	-1.315	1.315

to disturbance - animals habituated to humans do not flee, even at a very close distance (Recarte et al. 1998); this suggests that pampas deer accustomed to humans reacted less often to the presence of the observer. However, the less reactive individuals were probably recorded more times than the more reactive ones; therefore, it is possible that a greater percentage of animals are reactive. There are differences among responses of pampas deer populations to human activities. For example in Paraná (Brazil), the most frequent response to observer was fleeing (Braga et al. 2000); noteworthy, this population is "endangered" due to their small size and the existence of hunting episodes in the area (Braga & Kuniyoshi 2010).

According to Stankowich (2008) the tolerance to human presence is a predicted behavior for non-hunted ungulates; thus, hunted populations have significantly greater flight responses. This trend has been observed among cervids in the white-tailed deer (*Odocoileus virginianus*) (Kilgo et al. 1998), the elk (*Cervus elaphus*) (Bender et al. 1999) and the reindeer (*Rangifer tarandus*) (Baskin & Hjältén 2001). Pampas deer hunting is prohibited in Argentina, however poaching still persists (Miñarro et al. 2011); our results suggest tolerance to man and that no episodes of poaching occur within the study area.

In this study, logistic regression results suggest that the distance to the observer is the variable with greatest influence on flight, with groups fleeing more frequently the closer they are to the observer. Flight distance is the distance between animal and observer at the moment of flight initiation (Phillips 1993). It has been observed that ungulates under strong hunting pressure have longer flight distances (de Boer et al. 2004). Consequently, the fact that the pampas deer responded with fleeing from the observer only at short distances, would be another evidence that no poaching occurs within "El Centenario"; because if it had been poached it would flee at higher distances.

Pampas deer behavioral response was also associated with their group size, solitary individuals tending to flee and larger groups remaining (Table 2). This suggests human disturbance is a stressor that affects mainly lone animals. This was also observed in ungulate species in which groups took flight less often with increasing size (Malo et al. 2011); i.e. individuals may react less in situations of greater security, thus the flight is less likely in large groups (MacArthur et al. 1982).

In addition, the pampas deer response was linked to the group composition, with female groups fleeing mainly during birthing peak (November), seeking better protection for their fawn. Group patterns are also influenced by the life cycle according to the reproductive period (Semeñiuk & Merino 2015), which could also play an important role in their behavior. For instance, the variability among sexes in the flight could be linked to differences in their reproductive strategies; females prioritize the fawn survival, and are therefore more likely to react to a source of disturbance (Stankowich 2008). Moreover, Ungerfeld et al. (2015) observed that the social status of pampas deer hinds determined their relationship with man: high-ranked hinds avoided humans at greater distances. Likewise, the relationship between the hormonal status of males and the response to disturbance was studied in the Emas National Park, (Pereira et al. 2006): pampas deer from habitats outside the Park (frequent human disturbance) presented higher glucocorticoid concentrations (and stress), and exhibited higher flight distances, than the individuals inside the Park (lower human activity).

Thus, we conclude that most of the pampas deer groups remained on site; their behavioral response depended mainly on distances to observer, groups were more likely to flee at shorter distances. Poaching appears not to have important effects over this population; however, we recommend installing police stations on paved roads to perform a more effective control.

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